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Abstract

NATURAL AND SLIGHTLY ENRICHED URANIUM LATTICE STUDIES OF VOIDED METAL ROD CLUSTERS IN D_2O

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An extensive series of lattices consisting of voided rod cluster elements has been investigated in the subcritical facility MINOR. This experimental programme has formed the basis to check calculation methods for heavy water moderated and gas cooled pressure tube reactors. A detailed analysis was undertaken for an element consisting of 7 uranium metal rods enriched to 0.960% in U^{235}. This rod cluster is supported by a graphite structure which is surrounded by a pressure tube. An annular air gap separates the pressure from the calandria tube. This cluster presents a physical mockup of the fuel element to be used in the first charge of the Swiss experimental power station presently under construction at Lucens.

In order to obtain calculation methods which are of a more general usefulness and have a wider field of application the experiments specific to the Lucens reactor have been largely extended by varying a number of parameters of the lattice arrangements. The most important change consisted in a replacement of the enriched rods by natural uranium rods, leaving all structural material the same. The void content per cell was decreased by removing the calandria tube and increased by

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removing the graphite fillers. Finally some measurements with 4 rod clusters were performed. For all lattices several moderator to fuel volume ratios were investigated. For some or all of the lattices the following parameters were determined:

- The material buckling of single zone loadings by means of radial and axial flux plots (exponential). Some of the experiments were carried out in square as well as in triangular lattice geometry. Furthermore, the substitution technique was applied.
- Flux disadvantage factors of the different components of an element by means of flux fine structure measurements with Gold and Dysprosium foils.
- The epithermal component by means of the double foil technique.
- Cd-ratio of U^{238} by activation of depleted uranium foils.
- Axial fluxpeaking due to Al spacer pieces separating individual fuel slugs.

Theoretical interpretations of the experiments have been made on the basis of the two group four factor model. η is calculated according to the Westcott model. The fine structure of the thermal flux was obtained by P_3 theory adapted to the particular cluster geometry. The theoretical results are in agreement with the measurements for all the studied lattices within $\pm$ 2‰ in thermal utilization. Fast events were computed taking into account the heterogeneity of the element. Resonance escape probability p was obtained from a one group treatment assuming a constant slowing down density in the bulk moderator and calculating an extrapolation distance at the inner moderator surface with transport theory. Comparison with experiments indicates agreement within $\pm$ 1% in p. Diffusion coefficients have been calculated following Benoist's theory for the exact geometry by Monte Carlo techniques.

The measured bucklings have been compared with the calculations for all the investigated lattices. Agreement is within $20\text{-}30 \cdot 10^{-6}$ cm^{-2}.